INVESTIGATION CONCLUSION
ANOMALOUS SOIL SAMPLES
AT HUNTERS POINT NAVAL SHIPYARD
REVISION 1

April 2014

HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536

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Prepared by:

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EXECUTIVE SUMMARY

This report summarizes the investigation results and corrective actions taken by Tetra Tech EC, Inc. (TtEC) in response to a Navy inquiry into discrepancies between the first two sets of systematic sample results and the third set at the Former Building 517 site located at Hunters Point Naval Shipyard (HPNS).

The discrepancy was first identified during a routine telephone call on October 4, 2012. On that call, a Navy official with the Radiological Affairs Support Office (RASO) suggested that the third set of systematic samples for Survey Unit 2 within the Former Building 517 footprint (B517 SU-002) had been collected from locations different than the ones specified in the Final Status Survey Report. The conclusion was based on final systematic (post-remediation) soil sample results reported by the the on-site Department of Defense accredited laboratory. These results reported low potassium-40 (K-40) sample activity (i.e., < 5 picocuries per gram) coupled with low activity for radium-226 (Ra-226), bismuth-214 (Bi-214), and lead-214 (Pb-214) in 36 out of 36 samples. The set of systematic samples were purportedly collected post-remediation at a depth no more than 6 inches below ground surface (bgs). Since the on-site laboratory results were replicated by the off-site gamma spectroscopy laboratory, TestAmerica-St. Louis, the possibility of instrument error as the cause of the anomalous results was ruled out.

TtEC immediately responded to the Navy inquiry by conducting an investigation to determine the source of the discrepancy. The first step of the investigation consisted of potholing adjacent to the four locations reporting anomalous results in order to determine whether a contiguous fill layer was present near the surface and to compare soils observed in the potholes with those of the original final systematic samples, which had been archived. The final (or third) set of systematic samples was uniformly gray in color and similar to Franciscan-derived fill material.

Multiple lithologies were encountered in each pothole, and contiguous layers were not observed from location to location. Only one pothole contained light grayish soil similar to the archived material. Additional locations were potholed and sampled at multiple depths to determine whether the samples had been potentially collected at depths other than those indicated on the chain-of-custody (COC). Only 2 of 24 samples reported similar low K-40 concentrations and both were collected at depths greater than 6 inches bgs.

The second step of the investigation was to conduct a database review to identify other survey units with large proportions of low K-40 soil sample results. Over 70,000 results reported since 2008 were queried and approximately 2,500 samples were identified as meeting the criteria of low K-40 (< 5 picocuries per gram). The 2,500 results were then evaluated to determine whether the concentrations correlated with previous sample sets from the same area. Based on this evaluation, an additional 12 survey units at 3 additional sites in Parcels C and E were identified as survey units for which a high probability existed that the soil samples were not representative of the respective survey units. Seven other locations reported anomalously low K-40 concentrations for some samples within systematic sample sets and were identified for potential further evaluation as well.

Since laboratory error and subsurface conditions were ruled out as the cause of the discrepancies in K-40 results, the next step consisted of conducting interviews with sampling personnel to determine if human error was the cause. The TtEC Radiation Safety Officer (RSO) and the

Program Quality Control Manager (PQCM) conducted interviews with the individuals listed on the COCs, direct supervisors, members of the sampling crews, and laboratory workers. The results of the interviews were inconclusive.

Since the interviews did not provide any information on how the discrepancies in K-40 could have occurred, the investigation looked into the physical features of the suspect samples, including color and grain size. This investigation began at B517 SU-002. The samples with low K-40 from B517 SU-002 were uniformly gray in color and had similar grain size. The RSO, PQCM, site RSO Representative, and the Construction Manager conducted a site inspection at B517 SU-002, the North Pier, the former Building 707 Triangle Area, and various import fill piles to attempt to discern if the source of the low K-40 samples may have come from a stockpile or other convenient material source located on the site. Soil samples were collected from the North Pier, the former Building 707 Triangle Area, and the various import fill piles located at HPNS and were analyzed to determine if they had a similar radionuclide signature. Low K-40 values similar to those reported in the anomalous sample sets were found in samples of road base from the former Building 707 Triangle Area. The material's color was also similar to the suspect soil from B517 SU-002.

Subsequent investigation of other potential source materials and analyses revealed that grayish green drill cuttings found stockpiled on the ground floor of Building 253/211 have both lithologic and radioanalytical characteristics consistent with the suspect soil. The significance of this discovery was that if individuals decided to substitute samples from one source, it would be easier to do so within the confines of a building where the actions are less likely to be observed by others. Either the former Building 707 Triangle Area or the Building 253/211 drill cuttings, or a combination of both, may have been used as substitute soil samples; however, the investigators were unable to conclusively determine a source.

TtEC also resampled the 12 survey units with samples that were likely to not be representative of the survey unit, and four of the seven potential further evaluation sites, as identified in the database search. While duplicate soil samples are rarely correlative, the resampling was performed to provide representative soil sample data sets to compare against the anomalous results. Results from the resampling indicated significant differences in the K-40 values, which suggest that the initial data collected from those survey units may not have been representative of these survey units.

The remaining three potential further evaluation survey units that were not resampled were trench survey units. Uniform soil sample results are possible due to the complex fill history of HPNS, such as in samples collected from subsurface trench survey units where large lenses of homogeneous material are located. In addition, it is not unusual to have soil samples with low concentrations of K-40 in areas within HPNS, especially in samples collected from materials that have been derived from the Franciscan Formation or samples collected directly from the Franciscan bedrock. Soils and bedrock associated with the Franciscan are a distinctive dark gray to grayish green color. These materials are observed in the areas within Parcel C where the three former trench survey units identified for potential further evaluation are located.

Based on the investigation activities above, TtEC initiated a series of corrective actions as follows:

- Sampling personnel on the COC forms for anomalous samples were removed from TtEC projects. The two TtEC health physics supervisors responsible for the soil sample collection work were disciplined. All other project management personnel involved in the sampling process, including the project management team, quality control team, and radiation safety team, were issued letters of caution.
- All individuals directly involved in soil sample collection at HPNS attended refresher training on proper soil sample collection per the Sampling and Analysis Plan and Standard Operating Procedure (SOP) HPO-Tt-009, as well as proper filling out of COC forms.
- All individuals involved in soil sample collection, as well as every TtEC employee and subcontractor on the HPNS site, attended training on ethical behavior.
- TtEC resampled all 12 survey units recommended for resampling. Any survey units exhibiting activity concentrations exceeding the release criterion for a respective radionuclide of concern were remediated and resampled until all release criteria were met. All suspect data, including anomalous soil sample data and gamma static survey results, were rejected.
- TtEC resampled four of the seven locations identified for potential further investigation. These seven locations reported anomalously low K-40 concentrations for some samples within systematic sample sets. Further evaluation of photographs and samples from the remaining three trenches indicated that the low K-40 was likely due to the distinct Franciscan Formation visible in these trenches. The color and gradation of the samples from these trenches also support that they are from the Franciscan Formation.
- A protocol has been implemented that ensures a member of the HPNS quality control team conducts a surveillance of a minimum of 10 percent of final systematic sample collection. Issues identified during the surveillances are documented and corrected.
- A protocol has been implemented for the corporate RSO to be notified if sampling result trends are inconsistent with previous sampling results. This protocol includes K-40 and other radionuclides that are not radionuclides of concern.

Completion of these corrective actions has resulted in consistent, high-quality Final Status Survey results. These corrective actions ensured that additional samples have been collected and handled in full compliance with the Sampling and Analysis Plan. TtEC has not had a recurrence of the type of soil sample results that led to this investigation, indicating that the corrective actions have addressed the problem.

A chronology of events is presented on the following pages, beginning with identification of the data discrepancy in early October 2012 and ending with the responses to Navy comments incorporated into this April 2014 revised report.

INVESTIGATION CHRONOLOGY

October 4, 2012 — DATA DISCREPANCY IDENTIFIED

- During a phone call with the Navy, the Radiological Affairs Support Office points out a possible discrepancy in sampling results from the Survey Unit 2 within the Building 517 footprint (B517 SU-002).
- Anomalous samples have atypically low concentrations of K-40, Ra-226, Pb-214, and Cs-137.
- The possibility of laboratory instrument error is ruled out.
- TtEC pulls together a team to investigate.

October 5 through 8, 2012 — POTHOLING

- Potholes are excavated at four of the sample locations with anomalous results to determine if the samples were from the prescribed sampling depth.
- Multiple lithologies are encountered in each pothole.
- The hypothesis that individuals sampling soil may have sampled bedrock soil with low concentrations of K-40, Ra-226, and its progeny is not supported by potholing observations.

October 16, 2012 — SUBSURFACE SAMPLING

- Additional locations are potholed and sampled.
- Results do not support the hypothesis that the individuals may have sampled bedrock soil with low concentrations of K-40, Ra-226, and its progeny.
- The Corporate RSO and others review soil sample data from other HPNS sites around the former Building 517 Site.

October 15 through 19, 2012 — DATABASE REVIEW

- Investigative team members review soil sample results from the on-site database looking for similar anomalous data.
- The data review shows a pattern of consecutive samples with uncharacteristically low K-40, Ra-226, and progeny concentrations in 12 survey units at 3 additional sites in the Parcel C and E areas.
- The scope of the investigation is expanded to cover other survey units.

October 24 through November 28, 2012 — SYSTEMATIC SAMPLING

- The QCPM oversees the resampling of the systematic samples at B517 SU-002.
- The investigative team takes action to collect systematic samples in these areas to determine if the radionuclide signature of low K-40, Ra-226, and progeny could be replicated.
- The systematic sample results are substantially more elevated than the anomalous set of systematics, suggesting that the anomalous set of systematic samples is not representative of its respective survey unit.

Week of November 5, 2012 — INTERVIEWS

- To investigate the possibility of human error, the RSO and QCPM conduct interviews with individuals on the COCs for the anomalous soil sample results.
- Also interviewed are TtEC Health Physics Supervisors, subcontracted Radiation Control Technicians (RCTs), laboratory employees, quality control personnel, and the basewide supervisor.
- All individuals interviewed claim that all appropriate soil sampling techniques were used and all work was completed in an ethical manner.

November 7, 2012 — INSPECTION OF SITES WITH ANOMALOUS DATA

- Investigative team members conduct a visual inspection of soil surfaces at B517 SU-002, examine import fill soil, examine the North Pier, and examine the former Building 707 Site.
- The exposed layer of "road base" at the former Building 707 Site is found to be similar in color and composition to the anomalous soil samples from B517 SU-002.

November 7 and 8, 2012

VISUAL COMPARISON OF ARCHIVED SOIL SAMPLES

- The Corporate RSO and QCPM compare visual characteristics of different soil samples from the four different systematic sets collected within B517 SU-002.
- Because of color uniformity and the homogeneity of the low K-40, Ra-226, and progeny concentrations in an area with many visually distinct soil types, the investigators conclude that the soil samples were not collected from B517 SU-002.

November 2012

- The investigative team rules out various possible hypotheses for the anomalous soil samples leaving one possible explanation: The persons listed as the sample collectors on the COC forms, either by themselves or with others, collected soil samples in areas outside the designated survey units.
- Possible sources may be the "road base" in the SU 22/23 areas of the former Building 707 Site or the cuttings stored in Buildings 253/211.

November 29, 2012

- TtEC issues to the Navy an investigation report titled Investigation of Low Potassium Activity Concentrations in Soil Samples at Hunters Point Naval Shipyard.

December 3, 2012

- TtEC provides a copy of the investigation report to the Nuclear Regulatory Commission (NRC).

December 2012 through early 2013

CORRECTIVE ACTIONS

The following corrective actions are taken:

- The three remaining RCTs on the COC forms for anomalous samples are removed from TtEC projects. The two TtEC health physics supervisors responsible for the soil sample collection work are disciplined. All other project management personnel involved in the sampling process, including the project management team, quality control team, and radiation safety team, are issued letters of caution.
- All individuals directly involved in soil sample collection at HPNS attend refresher training on proper soil sample collection per the Sampling and Analysis Plan and SOP HPO-Tt-009, as well as proper filling out of COC forms.
- All individuals involved in soil sample collection, as well as every TtEC employee and subcontractor on the HPNS site, attend training on ethical behavior.
- TtEC resamples all survey units recommended for resampling. Any survey units exhibiting activity concentrations exceeding the release criterion for a respective radionuclide of concern are remediated and resampled until all release criteria have been met. All suspect data, including anomalous soil sample data and gamma static survey results, are rejected.
- TtEC resamples four of seven locations that reported anomalously low K-40 concentrations for some samples within systematic sample sets.
- A member of the HPNS quality control team conducts a surveillance of a minimum of 10 percent of final systematic sample collection. Issues identified during the surveillances are documented and corrected.
- A protocol is implemented for the corporate Radiation Safety Officer to be notified if sampling result trends are inconsistent with previous sampling results. This protocol includes K-40 and other radionuclides that are not radionuclides of concern.

September 2013

- The Navy provides comments to the November 29, 2012 investigation report.

October 2013

- Navy management holds a meeting with TtEC management to provide comments on the 2012 investigation report and to include a status of the corrective actions.

October 21, 2013

- TtEC issues a report titled Investigation of Anomalous Soil Samples at Hunters Point Naval Shipyard. The report, provided to the Navy and NRC, contains additional information, including the status of the corrective actions.

December 9, 2013

- The Navy requests additional clarification of the Investigation Report issued October 2013.

January 9, 2014

- TtEC responds to Navy comments.

February 2014
- The Navy asks a question related to Survey Units 707-15 and -20 and whether they will be included in the Investigation Report. The Navy also requests TtEC's concurrence to share the Investigation Report with the Base Closure Team (BCT).
- TtEC responds to the additional Navy comment, stating it will not include a discussion of Survey Units 707-15 and -20 because those survey units were not flagged as potentially anomalous, so were not included as part of the investigation. However, these survey units were addressed through TtEC's technical peer review and quality control review process during development of the Final Status Survey report. TtEC also provided the Navy concurrence with sharing the investigation report with the BCT. Because the report is being shared with the BCT, TtEC added an executive summary and updated the report with supplemental information.

March 3, 2014
- TtEC issues a report titled Investigation Conclusion, Anomalous Soil Samples at Hunters Point Naval Shipyard. The report is provided to the Navy and NRC.

April 23, 2014
- TtEC updates the Executive Summary and issues a report titled Investigation Conclusion, Anomalous Soil Samples at Hunters Point Naval Shipyard, Revision 1.

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INTRODUCTION

This Root Cause Analysis (RCA) was undertaken to determine whether the final systematic soil samples from Survey Unit 2 of the Former Building 517 Site had been collected at the locations specified in the Final Status Survey (FSS) report. The analysis of evidence from both the past sampling and from the investigation will help illuminate the causes that contributed to any discrepancies. During the investigation, Tetra Tech EC, Inc. (TtEC) identified additional survey units at Hunters Point Naval Shipyard (HPNS) that exhibited anomalous soil sample results. TtEC investigated each set of anomalous results; resampled and completed additional remediation, where necessary; and revised and resubmitted reports for these areas. TtEC also developed corrective actions to address the possible root causes for these anomalous samples to prevent recurrence of similar problems.

EVENT DESCRIPTION

On October 4, 2012, during a routine call with the Navy's Radiological Affairs Support Office (RASO), a RASO official suggested that the final systematic samples for Survey Unit 2 (within the Building 517 footprint) had been collected from locations different than the ones specified in the FSS report. Figure 1 is a map showing the sample locations and remediated areas.

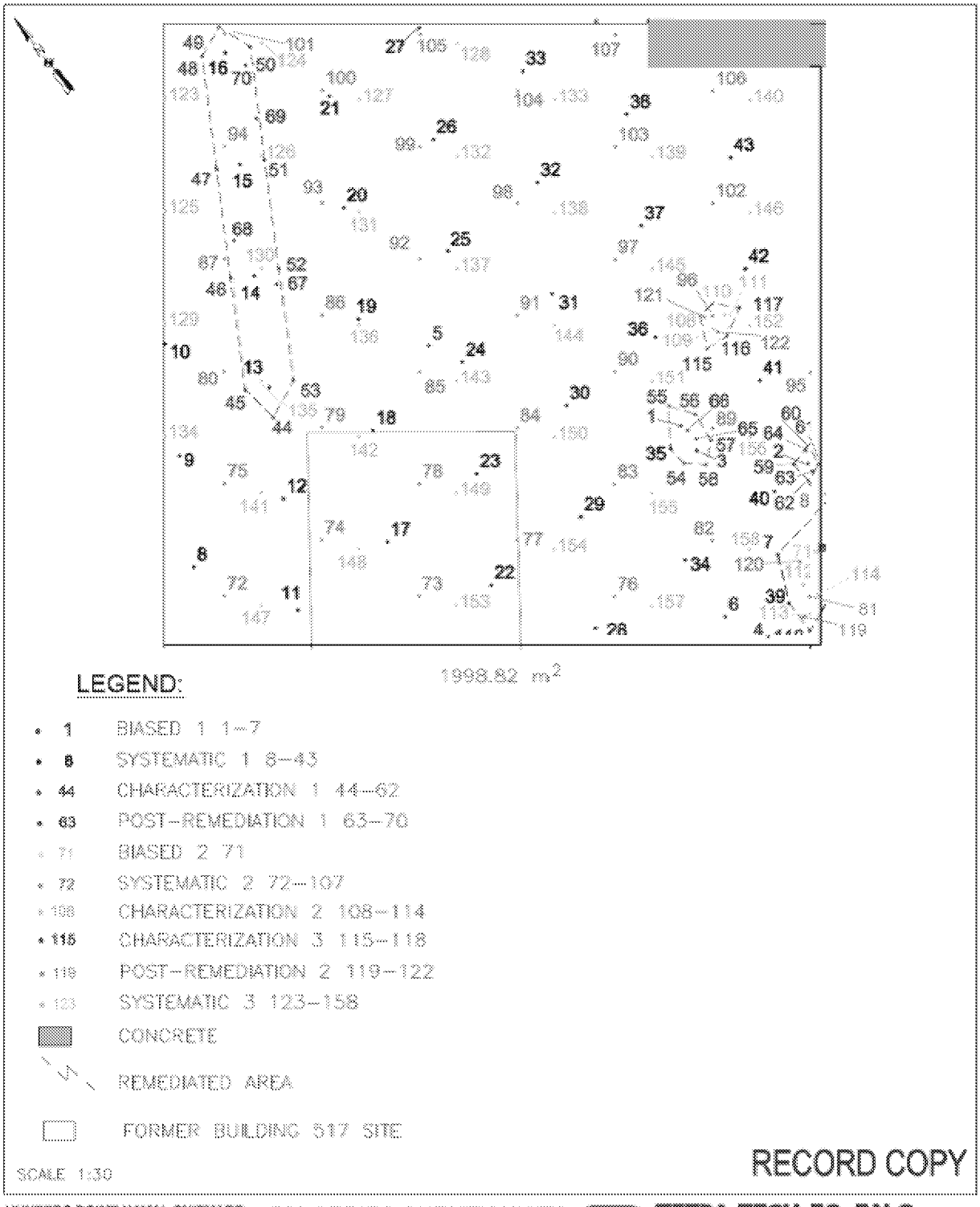
This suggested discrepancy was based on low potassium-40 (K-40) sample activity (< 5 picocuries per gram [pCi/g]) coupled with low radium-226 (Ra-226), bismuth-214 (Bi-214), and lead-214 (Pb-214) reported by the on-site Department of Defense accredited laboratory in the set of systematic samples collected post-remediation at a depth of no more than 6 inches below ground surface (bgs) for Building 517 Survey Unit 2 (B517 SU-002). These samples are described as "anomalous" soil samples because the sample results are not consistent with the expected sample results from the survey unit in question. These samples, and other samples meeting these conditions, are referred to as "anomalous samples" throughout this report

The determination of consistency was based on the professional judgment of the Radiation Safety Officer, and on comparison of the results with results from other soil samples collected concurrently or previously in the associated survey unit. Due to the complex fill history of HPNS, the soil sample results in some cases can be expected to be somewhat uniform, as in some surface survey units where the fill material appears homogeneous. In other cases, such as trench survey units that cut through several layers of different fill materials, the soil samples would be expected to exhibit a more varied distribution.

A subset of "anomalous samples" is often referred to as "low K-40" samples, because of an atypical concentration of low K-40, Ra-226, Bi-214, Pb-214, and cesium-137 (Cs-137) activity concentrations across a large number of soil samples within a survey unit. Such soil samples have been, and continue to be, collected periodically in various locations at HPNS, most notably along the 1935 shoreline (Figure 2 of Attachment 1). This was likely due to the expansion of the HPNS through use of fill materials derived from native Franciscan bedrock from the inland hill area. A description of the site conceptual model for the "low K-40" soil present throughout the site, especially along the boundary of the HPNS 1935 shoreline located in Parcel C, is included in Attachment 1. A listing of "low K-40" soil samples with a statistical analysis of "low K-40" soil samples and all soil samples collected since January 2008 is contained in Attachment 2.

FIGURE 1

BUILDING 517 SURVEY UNITS



HUNTERS POINT NAVAL SHIPYARD
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500 SERIES SURVEY UNITS
CLASS 1 SURVEY UNIT
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Since January 1, 2008, approximately 2,500 samples meeting the definition of "low K-40" samples have been collected at HPNS.

The activity levels from various isotopes from the B517 SU-002 anomalous samples were not representative of previous systematic samples collected from the same trench unit, and were conspicuous in that the sample activities were consistent and unvarying across 36 of 36 samples. As shown in Attachment 3, the set of final systematic samples from B517 SU-002 had mean, median, and standard deviations for K-40 of approximately 1.78 pCi/g, 1.75 pCi/g, and 0.6 pCi/g, respectively. In contrast, the previous set of systematic samples collected on February 2, 2012, produced mean, median, and standard deviations for K-40 of 16.93 pCi/g, 15.83 pCi/g, and 7.62 pCi/g, respectively.

Since the on-site laboratory results were replicated by the off-site gamma spectroscopy laboratory, TestAmerica-St. Louis, the possibility of instrument error as the cause of the discrepancy was ruled out.

BACKGROUND

Geologic Setting

In the late 1930s and early 1940s, fill was used to create the land surface beyond the historic shoreline at HPNS. This fill ranged from silty and sandy clays with gravel to poorly graded sands, boulders, and debris deposits. A majority of the coarse fill material was locally derived from the Franciscan Formation bedrock consisting of serpentinite, greenstone, shale, greywacke, and chert. Competency of the bedrock material encountered near the surface at Parcel E ranges from low to very hard, and fractures are common. The weathered material is decomposed and is friable. The unweathered Franciscan bedrock is hard and fractured. In general, samples collected from Franciscan-derived materials report low radiological readings. The bedrock material is often referred to as "serpentinite" by the HPNS field workers.

Former Building 517 Site Final Status Survey Summary

The Former Building 517 Site is located in Parcel E at HPNS, San Francisco, California. The original building measured approximately 50 feet by 50 feet. The Former Building 517 Site was previously used as a brig (jail) and the Naval Radiological Defense Laboratory Cobalt Animal Irradiation Facility.

The radionuclides of concern at the Former Building 517 Site are Cs-137, cobalt-60, and strontium-90. Due to its potential presence, Ra-226 is included as an additional radionuclide of concern. These radionuclides cover alpha, beta, and gamma emitters, all three possible kinds of radioactivity that could be emitted by these radionuclides.

An FSS for the Former Building 517 Site was designed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (NUREG-1575; DoD et al. 2000). To perform the survey, the Former Building 517 Site was divided into two Class 1 survey units. Class 1 survey unit 1 consisted of a concrete slab. After the survey operations for the Class 1 concrete survey unit were completed, the concrete surface was removed to allow surveying of the Class 1 soil survey unit beneath the concrete. Although no Class 2 survey surrounding the Class 1 soil survey was performed, the designated Class 1 soil survey area extended beyond the foundation footprint of the Former Building 517 Site.

INVESTIGATIVE TEAM AND METHODS

TtEC initiated the investigation to evaluate potential causes for the discrepancy. The investigation team consisted of:

- Erik Abkemeier, PE, CHP, CSP, CHMM, Nuclear Regulatory Commission (NRC) license Radiation Safety Officer (RSO)
- Greg Joyce, CQM, Program Quality Control Manager
- Adam Berry, Radiation Safety Officer Representative
- Rich Kanaya, Project Quality Control Manager
- Rick Weingarz, Assistant Project Manager

For this RCA, the investigative team used potholing, additional subsurface analysis, database review, on-site interviews, and visual comparison of soil samples.

CHRONOLOGY OF EVENTS/TIMELINE

October 5, 2012

B517 SU-002 Subsurface Investigation

Because the composition of the backfill within Parcel E may consist of bedrock debris and the depth of the actual bedrock can be extremely variable, the first step in the investigation was to determine if the set of systematic samples with the anomalous readings was collected from a specific layer in the subsurface that may or may not have been at the depth prescribed for sampling. The sampling depth for the systematic samples, as described in Standard Operating Procedure (SOP) HPO-Tt-009, is 15 centimeters (6 inches) bgs. The SOP is included as Attachment 4.

B517 SU-002 was located and marked out by TtEC on-site engineers. Final systematic sample locations and associated building footprints (B-509/B-517) were also located and marked. Once all markings were completed, stakes and rope were erected to establish a perimeter around SU-002. Signs reading "Do Not Enter" were hung around the perimeter to negate foot and equipment traffic.

October 5 to 8, 2012

Locations #141, #148, #149, and #155 Potholes

On October 8, 2012, potholes were excavated with a backhoe to a depth of 3 feet bgs at four of the sample locations with anomalous results (#141, #148, #149, and #155) to identify lithology (Figure 1). Excavation at each location was performed in 6-inch lifts, with photographs and measurements collected between lifts. A geologist was present to aid in the identification of lithology. Multiple lithologies were encountered in each pothole. This created distinct layers of differing material types which varied with depth. A summary of the initial investigation and photographs of the sample locations potholed are included in Attachment 5.

In tandem with securing the B517 SU-002 area on October 5, all archived samples taken from the survey unit were pulled aside and secured for comparison with the lithology observed in the potholes. In general, the archived samples are light gray in color. Photographs of samples pulled from the archive for locations #141, #148, #149, and #155 are included in Attachment 5.

The samples matched the lithology at only one location (#155) where a lens of light grayish bedrock material was observed. The hypothesis that individuals sampling soil may have either consciously or accidentally sampled bedrock soil that had low concentrations of K-40, Ra-226, and its progeny was not supported by observations from the potholing at locations #141, #148, and #149.

October 16, 2012

B517 SU-002 Subsurface Sampling

Since the potholing was not conclusive at locations #141, #148, #149, and given the potential for variability in fill materials that may be present across B517 SU-002, additional locations in different quadrants of B517 SU-002 were potholed using a backhoe and sampled on October 16, 2012. The potholes were advanced in 6-inch intervals to a depth of 3 feet bgs. Samples were collected at 6-inch intervals to acquire information about the radionuclide concentrations at multiple depths to verify if sampling technique may have been a factor in the anomalous soil sample results. All sampling was verified and documented by an independent party, Rich Kanaya, Project Quality Control Manager, in surveillance reports included as Attachment 6. Photographs of the potholes are included as Attachment 7.

A summary of the Bi-214, Pb-214, Ra-226, and K-40 concentrations is provided in Table 1. A pothole sample map is shown as Figure 2.

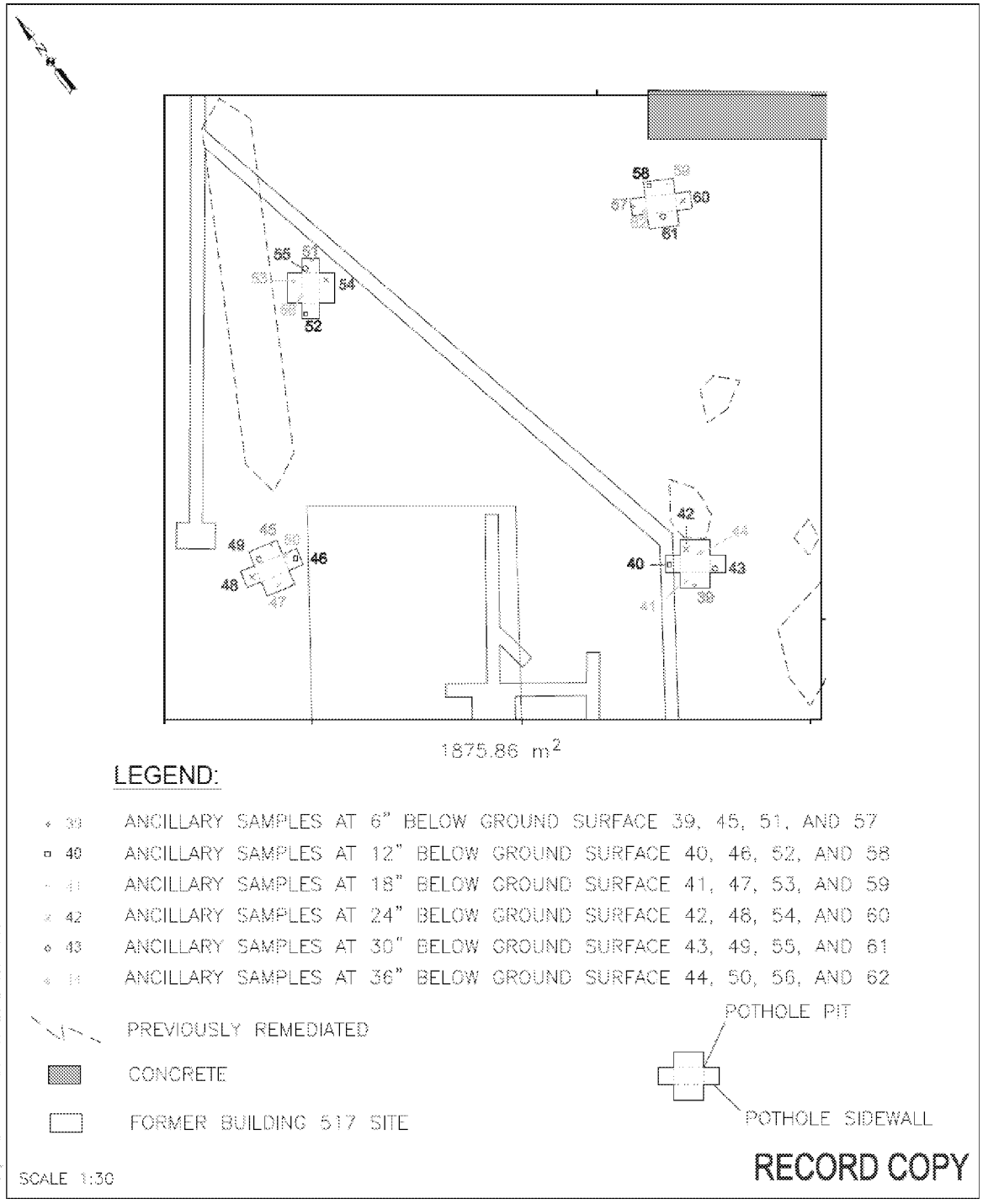
TABLE 1

FORMER BUILDING 517 SITE SU-002 INVESTIGATIVE POTHOLE RESULTS

	Sample ID	Bi-214	Pb-214	Ra-226	K-40
6 inches	07AB517-039	0.334	0.4707	0.7022	11.09
	07AB517-045	0.4849	0.6182	0.9035	11.89
	07AB517-051	0.4115	0.5577	0.819	13.81
	07AB517-057	0.3598	0.2577	0.5537	11.45
12 inches	07AB517-040	0.4547	0.4334	0.7448	12.73
	07AB517-046	0.9698	0.9118	1.245	12.45
	07AB517-052	0.2658	0.3691	0.3634	10.76
	07AB517-058	0.3278	0.2753	0.5787	12.08
18 inches	07AB517-041	0.3203	0.4782	0.752	11.77
	07AB517-047	0.07622	0.1602	0.4654	9.22
	07AB517-053	0.3269	0.3247	0.6957	7.926
	07AB517-059	0.101	0.1701	0.6186	8.725
24 inches	07AB517-042	0.01964	0.02277	0.06388	0.476
	07AB517-048	0.04757	0.1221	-0.1024	10.2
	07AB517-054	0.3334	0.2329	0.5851	6.622
	07AB517-060	0.4268	0.3673	0.5442	12.14
30 inches	07AB517-043	0.1168	0.1369	0.1389	5.773
	07AB517-049	0.1962	0.2484	0.4376	8.74
	07AB517-055	0.1217	0.1549	0.4367	8.374
	07AB517-061	0.08145	0.1993	0.1689	6.603
36 inches	07AB517-044	0.08985	0.1425	0.6409	10.85
	07AB517-050	0.6213	0.591	1.016	9.783
	07AB517-056	0.2989	0.3047	0.3685	10.39
	07AB517-062	-0.02878	0.06787	0.1407	4.778
	K-40 < 5 pCi/g				

FIGURE 2

POTHOLE SAMPLE MAP



The complete set of soil sample results is available upon request.

Given that all 36 final systematic samples collected on April 10, 2012, in B517 SU-002 showed K-40 at concentrations less than 5 pCi/g, it would be expected that sample results from the four quadrant locations at 6-inch intervals to depths of 3 feet bgs would have similar results. However, only two locations had results similar to the final systematic results, and both of these locations were significantly deeper than the targeted 6 inches bgs.

B517 SU-002 Subsurface Investigation Conclusions

The hypothesis that individuals sampling soil may have either consciously or accidentally sampled bedrock soil that had low concentrations of K-40, Ra-226, and progeny was not supported by observations from the potholing or the subsurface sampling. No lithological evidence suggests that a bedrock soil layer exists, light gray in color, that is contiguous across B517 SU-002 at depths less than 2 feet bgs, which would account for anomalous readings in all 36 final systematic sample locations. In addition, even though two results from subsurface sampling were similar to the anomalous K-40 results, neither sample was located at a depth that could be credibly attributed to misjudging a 6-inch sampling depth.

October 16, 2012

Investigation to Identify Other Sites with Low K-40 Data

While waiting for the results from the subsurface sampling, the NRC licensed RSO, Erik Abkemeier, and others reviewed soil sample data collected from other HPNS sites surrounding the Former Building 517 Site. The review looked specifically for soil samples with K-40 concentrations less than 5 pCi/g.

Previous to this investigation, patterns of radionuclide concentrations were not specifically analyzed by anyone on the HPNS team. Concentrations of Ra-226 and its progeny were carefully monitored on gamma spectroscopy results to ensure that the Ra-226 release criterion was not exceeded. As K-40 is not a radionuclide of concern, K-40 concentrations were not monitored other than in conjunction with evaluating gamma scan and static readings that appear more elevated than usual but do not exhibit elevated concentrations of any of the radionuclides of concern.

October 15 through 19, 2012

Database Review

From October 15 through October 19, Erik Abkemeier, George Chiu, and Thorpe Miller reviewed soil sample results from the on-site database, as well as survey unit sampling maps. The review was to:

- Identify areas with similar anomalous K-40, Ra-226, and progeny concentrations that do not correlate with previous samples in the area in the event that multiple soil sample sets were collected.
- Evaluate soil sample sets exhibiting similar radionuclide concentrations that appear divergent from other soil samples in the area.

The key radionuclides, sampling date, and individual listed as the sample collector on the sample chain of custody are provided in the spreadsheets in Attachment 3. Note that not all survey units

listed in the spreadsheet show anomalous soil sample results. Some survey units are listed for comparison of soil sample results for other survey units in the same general area.

The review of the data showed a pattern of consecutive samples with uncharacteristically low K-40, Ra-226, and progeny concentrations in 12 survey units at 3 additional sites in the Parcel C and E areas. In many of these areas, previous systematic samples collected in the same vicinity did not show the same low K-40 concentration. As these anomalies are consistent with the K-40 sample concentrations as evidenced in B517 SU-002, the scope of the investigation was expanded to cover other survey units.

October 24 through November 28, 2012

Additional Systematic Sampling

From October 24 through November 28, the HPNS team took action to collect systematic samples in these areas to determine if the radionuclide signature of low K-40, Ra-226, and progeny could be replicated. An additional surveillance was conducted by Greg Joyce on October 24, 2012, for B517 SU-002. The surveillance report is contained in Attachment 8. A listing of survey units that warranted further investigation is provided as Table 2. Soil sample survey maps for the former Building 517 Site, Building 707 Triangle Area (707 Area), Shack 79/80, and North Pier are included in Attachment 3.

TABLE 2

SURVEY UNITS RECOMMENDED FOR RESAMPLING

Area	Survey Unit	Sample Numbers	Date Collected	COC Radiological Technician
517	2	123-158	10-Apr-12	Jeff Rolfe
707	9	59-78	08-Jun-11	Jeff Rolfe
707	16	67-86	07-Jun-11	Jeff Rolfe
707	17	64-83	08-Jun-11	Jeff Rolfe
707	22	81-100	12-Aug-12	Anthony Smith
707	23	5-24	31-Jul-12	Jeff Rolfe
North Pier	1	28-47	31-May-12	Ray Roberson
North Pier	7	30-49	04-Jun-12	Justin Hubbard
North Pier	8	32-51	31-May-12	Ray Roberson
North Pier	10	27-46	31-May-12	Ray Roberson
North Pier	11	27-46	31-May-12	Ray Roberson
79/80	2	3, 5-6, 8-22	04-Apr-12	Jeff Rolfe

Additional Systematic Sampling Results

Results, including calculation of the mean, median, and standard deviation values for the complete systematic sample data sets, are contained in the spreadsheets of Attachment 3. The systematic sample results collected as a result of this investigation are substantially more elevated than the anomalous set of systematics, suggesting that the anomalous set of systematic samples is not representative of its respective survey unit.

For example, in the set of final systematic samples from B517 SU-002 that led to this investigation, the mean, median, and standard deviation for K-40 concentrations were approximately 1.78 pCi/g, 1.75 pCi/g, and 0.6 pCi/g, respectively. The set of systematic samples collected as part of this investigation on October 24, 2012, produced results for K-40

concentration mean, median, and standard deviations of 15.16 pCi/g, 14.77 pCi/g, and 5.13 pCi/g, respectively.

Note that in some cases, such as in the Shack 79/80 Survey Unit 2, soil samples collected as a result of the anomalous set of systematic samples identified radionuclides of concern at a level exceeding a radionuclide-specific release criterion. In these cases, additional characterization samples were collected to bound the extent of contamination and remediate the affected area. These soil sample results are included in Attachment 3 as well.

Table 3 is a listing of survey units showing some low K-40 concentrations but not exhibiting the need for collection of an entire systematic sample set, due either to a mix of more elevated K-40 concentrations and/or no other sets of samples that conflict the low K-40 results. These survey units warrant further review and may require resampling.

TABLE 3

SURVEY UNITS WITH LOW K-40 CONCENTRATIONS FOR POSSIBLE RESAMPLING

Area	Survey Unit	Sample Numbers	Date Collected	COC Radiological Technician
500	3	45-56	4/4/12, 4/13/12	Jeff Rolfe/Anthony Smith
707	3	37-56	24-Feb-11	Jeff Rolfe
707	13	31-50	4-Mar-11	Jeff Rolfe
Parcel C Trench	234	1-18	18-Nov-11	Joe Cunningham
Parcel C Trench	238	18-35	12-Apr-12	Joe Cunningham
Parcel C Trench	242	25-42	17-Apr-12	Joe Cunningham
Parcel C Trench	302	5-22	22-May-12	Joe Cunningham

Note that the Building Area 500, Survey Unit 3 samples are the result of post-remediation samples collected at a deeper point than surface samples. The final set of systematics in that survey unit showed a typical radionuclide concentration distribution for K-40, Ra-226, and progeny. These samples lend credence to the possibility that soil samples from B517 SU-002 were dug below a depth of 6 inches. As that theory has been effectively disproven, these soil samples are questionable as well.

Additionally, the Parcel C trenches listed in Table 3 have been backfilled and are not easily accessible. Because trenches to remove pipe are at a depth that frequently intersects with the native bedrock soils, there is a possibility that the soil type at which the trench samples were collected is of a uniform naturally occurring radionuclide concentration, such that the samples are all valid; however, these trenches do have sets of final systematic samples that are anomalous when compared to other survey units. Recommendations regarding these trenches are included in Attachment 19.

Week of November 5, 2012

On-Site Interviews and Examination of Samples

Because laboratory error and the presence of a near-surface contiguous bedrock soil were ruled out as a possible cause for the B517 SU-002 discrepancy and results from vertical sampling and another set of systematic samples, collected within feet of the anomalous locations, did not report

similar low K-40 results, the next step was to investigate the potential of human error as the cause for the discrepancies.

During the week of November 5, 2012, Erik Abkemeier and Greg Joyce conducted investigations at HPNS consisting of:

- Interviews with individuals listed on the chains of custody for the anomalous soil samples listed in Table 2, as well as direct supervisors, members of the sampling crews, and individuals listed on the receiving end of the soil samples at the Curtis and Tompkins on-site laboratory
- Inspection of the sites with anomalous systematic sample sets to determine the homogeneity of surface soil type as well as examine the soil strata in the potholes dug in B517 SU-002
- Visual comparison of all sets of systematic soil samples collected at B517 SU-002

Interviews with Personnel

Interviews were conducted with a predetermined set of questions, including prompts for any knowledge of improprieties or unethical behavior, as well as a lead-in by Erik Abkemeier and Greg Joyce describing the situation, the seriousness of the situation, and the likelihood of follow-up questions from other entities. Individuals were often asked follow-up questions to further understand the sample collection, sample receipt, or sample preparation process, as well as to probe for any direct or indirect pressures. A synopsis of the interview with each individual is included in Attachment 9.

Field Employees

The individuals interviewed as a part of the teams collecting soil samples in the field consisted of TtEC Health Physics Supervisors, Steve Rolfe and Justin Hubbard; Radiological Survey & Remedial Services, LLC (RSRS) subcontracted Radiation Control Technicians (RCTs), Jeff Rolfe and Ray Roberson; and TtEC laborers Jorge Colonel, Reggie Young, and Jeff Langston. Although listed on the chains of custody for some anomalous systematic soil sample survey units, Anthony Smith and Joe Cunningham were not interviewed as they were no longer working at the HPNS project site at the time of the investigation. Shortly after this investigation, Ray Roberson passed away.

From these interviews, the following points were corroborated consistently:

- Only HPNS Health Physics Supervisors or RCTs fill out chain-of-custody paperwork.
- HPNS Health Physics Supervisors give direction on what tools to use, consisting of picks, shovels, chipper hammers, and sometimes backhoes for hard surfaces, as well as what depth to collect the samples.
- Sample locations are selected using Visual Sample Plan software as described in the approved work plans. Engineers provide a map and orange markings with numbers on the ground in each survey unit to mark areas where samples are to be collected and field crews sampled only where the sample location was marked.
- Only one to two sets of survey unit samples could be collected in one day. Collecting greater numbers of samples would be difficult.

- No one knew of any sample collection outside the points that samples were marked to be collected or of sampling outside the survey unit sites.
- The teams were under no pressure or schedule deadlines for completing survey units. The only indication of any sense of urgency came from Steve Rolfe, who had been told that there had been no completed work that could be invoiced for Parcel E in some time.

During these interviews, both Justin Hubbard and Ray Roberson stated that collection of more than two sets of systematic samples in one day would be difficult. However, the investigation revealed that Ray Roberson was listed on chains of custody for four sets of systematic samples from the North Pier, which is extremely rocky and difficult to sample, as well as an additional trench segment survey unit, all on May 31, 2012. These chains of custody are in conflict with the statements made by these two individuals.

Laboratory Employees

The individuals interviewed as a result of being listed on the chains of custody for sample receipt of anomalous systematic soil samples at the Curtis and Tompkins on-site laboratory were Phil Smith and Robin Fluty, laboratory supervisors, and Jeff Fluty, Andy Alexander, and Jon Alexander, laboratory technicians. All are Curtis and Tompkins employees.

For these interviews, the following points were consistently corroborated:

- Verifying the sample bag numbers against the chain-of-custody forms is an established process.
- Sample preparation is an established process.
- Sample bags are stored in the receipt or processing Conex to which only the laboratory technicians and laboratory manager have lock access.
- The Conex is never left unattended or unlocked.
- Laboratory employees have minimal knowledge of where soil samples are collected in the field.
- Laboratory employees have minimal knowledge of whether specific soil samples are above or below a release criterion for a radionuclide of concern.
- All laboratory technicians can perform all functions, all sample receipt, sample analysis, and gamma spectroscopy.

Other HPNS Employees

Additionally, Bryan White, Basewide HPNS Supervisor at the time of investigation and former Radiological Quality Control personnel, and Jarvis Jensen, Health Physicist, were interviewed. Bryan White provided background and insight into the manner in which soil samples are typically collected, as he had performed quality control surveillances of the evolution in the past. He knew of no intentional soil tampering, and did not believe anyone on-site would engage in such an activity. Jarvis Jensen was not aware of any known or rumored soil sample tampering. He had originally suspected the anomalous soil sample results found in the B517 SU-002 had been the result of digging too deep because he believed it was fairly common knowledge among the RCTs that the "blue-green" serpentinite rock provided favorably low Ra-226 results.

November 7, 2012

Inspection of Sites with Anomalous Data

On November 7, 2012, Erik Abkemeier and Greg Joyce accompanied Construction Manager Dennis McWade and Radiation Safety Officer Representative Adam Berry to inspect B517 SU-002, various import fill piles, the North Pier, and the 707 Site.

Examination of Soil Surfaces at Former Building 517 Site, Survey Unit 2

A visual inspection of the surface soils at B517 SU-002 showed that there appears to be a number of different soil types throughout the surface area, of which little appears to match the gray soil from the anomalous set of systematic samples. Additionally, the four potholes contained materials in a variety of colors, but the depths were not consistent. Therefore, collecting an entire set of 36 systematic samples in a contiguous soil stratum at depth, by accident, seemed unlikely.

Examination of Import Fill Piles

The same individuals visited the site of several import fill piles to look for soil that appeared similar to the soil of the anomalous B517 SU-002 samples. Soil samples collected for gamma spectroscopy analysis from the import fill piles did not have any results similar to the anomalous sample results.

Examination of North Pier

The North Pier had been covered by crushed asphalt at the conclusion of remediation several months earlier; however, it was evident where samples had been collected as part of the investigative process. A test pit was dug to a depth of 3 feet bgs. The soil beneath the asphalt was a mixture of rocks, gravel, and clays, and was not consistent throughout the area. Results from the test pit on the North Pier are shown in the following Table 4, and sampling locations are shown on Figure 3. Photographs are provided in Attachment 10. No results at any depth were comparable to the anomalous soil samples with low concentrations of K-40, Ra-226, and progeny.

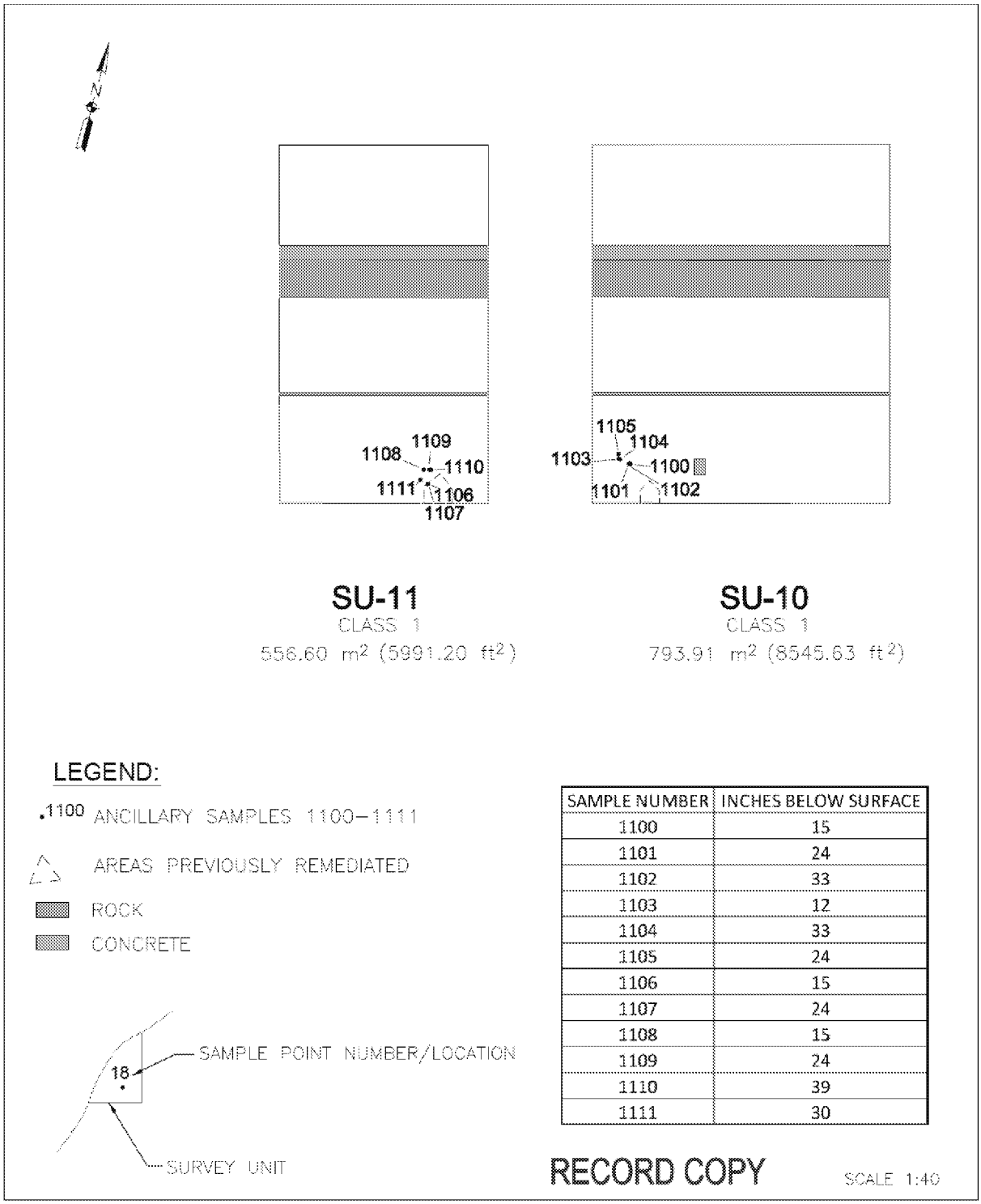
TABLE 4

NORTH PIER TEST PIT SAMPLES COLLECTED TO A DEPTH OF 3 FEET

Sample ID	K-40 (pCi/g)	Ra-226 (pCi/g)	Cs-137 (pCi/g)	Bi-214 (pCi/g)	Pb-214 (pCi/g)
07A-SB04-002	13.73	0.5723	0	0.5101	0.4946
02ANPR-1100	6.796	0.3756	-0.01209	0.0923	0.2235
02ANPR-1101	9.391	0.3323	-0.008652	0.2755	0.4686
02ANPR-1102	9.294	0.4989	-0.006876	0.4131	0.3777
02ANPR-1103	6.227	0.3655	-0.0004954	0.09775	0.1739
02ANPR-1104	8.076	0.3324	0	0.3696	0.2369
02ANPR-1105	8.011	0.1466	0	0.3387	0.3623
02ANPR-1106	10.64	0.5653	-0.006999	0.3513	0.4925
02ANPR-1107	10.51	0.4341	0.007666	0.3817	0.5214
02ANPR-1108	17.77	1.359	0.01339	0.4399	0.5899
02ANPR-1109	6.758	-0.1163	-0.004885	0.1066	0.2448
02ANPR-1110	7.906	0.4756	0.004713	0.143	0.2897
02ANPR-1111	7.847	0.5883	0.001557	0.3008	0.3195

FIGURE 3

NORTH PIER SAMPLE LOCATIONS



SAMPLE NUMBER	INCHES BELOW SURFACE
1100	15
1101	24
1102	33
1103	12
1104	33
1105	24
1106	15
1107	24
1108	15
1109	24
1110	39
1111	30

Examination of Site 707

Due to performance of the Task-specific Plan for the Building 707 Triangle Area Remedial Action Support and Final Status Surveys, the 707 Site had varying degrees of remediation performed, so that there were different depths across the area. An exposed layer of "road base," looked similar in color (gray) and composition (relatively homogeneous) to the soil samples from B517 SU-002. Photographs are provided in Attachment 11, and sample locations are shown on Figure 4. Samples of the road base were analyzed, and results are shown in Table 5.

FIGURE 4

SITE 707 TRIANGLE MAP

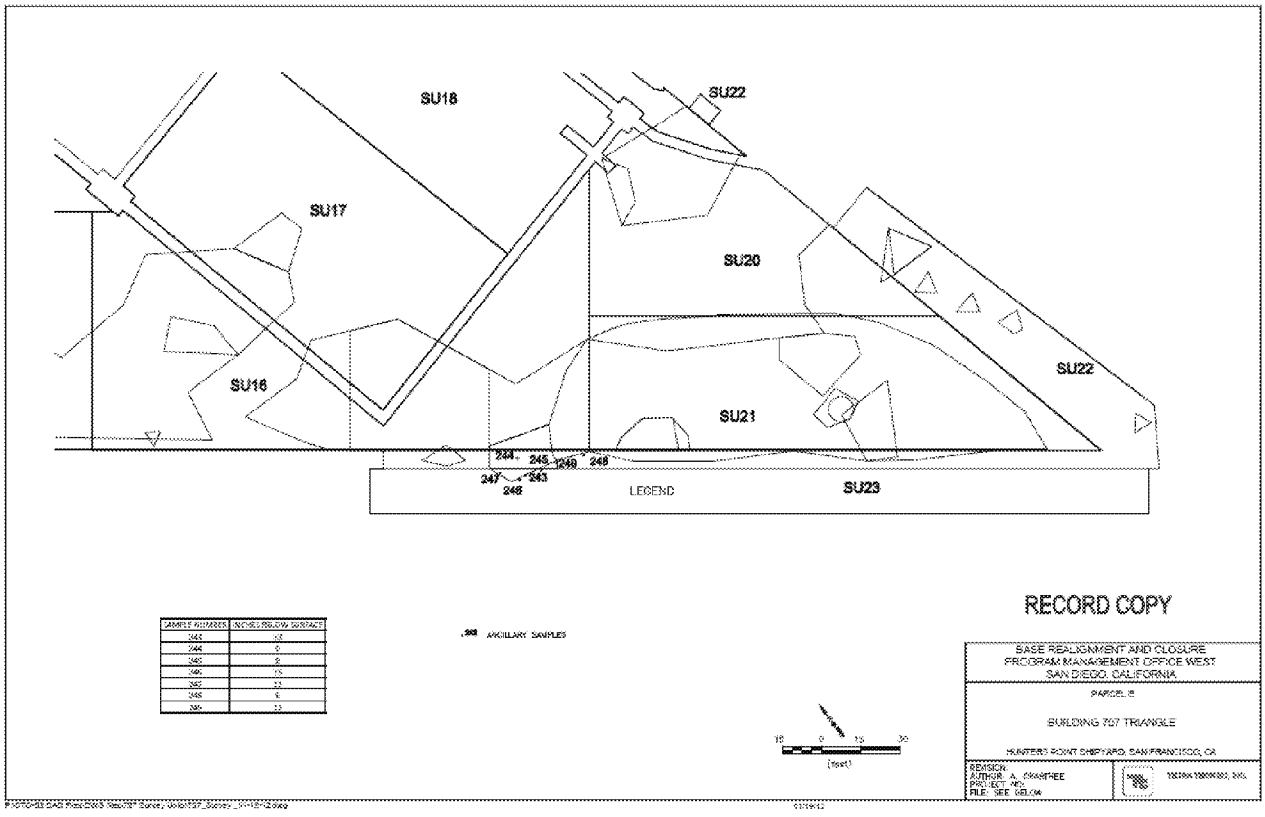


TABLE 5

SITE 707 ROAD BASE SAMPLE RESULTS

Sample ID	K-40 (pCi/g)	Ra-226 (pCi/g)	Cs-137 (pCi/g)	Bi-214 (pCi/g)	Pb-214 (pCi/g)
03AB707-243	0.9625	-0.0327	0	0.04739	0.05083
03AB707-244	10.66	0.2727	0.0003179	0.2967	0.2651
03AB707-245	1.387	-0.005944	0	0.05911	0.003418
03AB707-246	1.767	0.1753	-0.003111	0.04795	0.1434
03AB707-247	4.043	0.3342	0.002867	0.09128	0.2231
03AB707-248	4.025	0.2588	0	0.2039	0.2427
03AB707-249	1.819	0.2468	0.00544	0.1213	0.1636

As the results of all but one sample seemed to closely match the low K-40, Ra-226, and progeny concentrations seen in the anomalous results, this site is a potential source of the material. Note that the only result that did not match the radionuclide signature (Sample ID 03AB707-244) was collected at the surface, and not in the actual "gray road base" stratum.

November 7 to 8, 2012

Visual Comparison of B517 SU-002 Archived Soil Samples and Associated Tuna Cans

On November 7 to 8, 2012, Erik Abkemeier, Greg Joyce, and Rick Weingarz compared visual characteristics of different soil samples from the four different systematic sets collected within B517 SU-002. Samples 8 to 43 were the original set of systematics, samples 72 to 107 were the second set of systematics, samples 123 to158 were the third set of systematics (with anomalously low K-40, Ra-226, and progeny concentrations), and samples 159 to 194 were the fourth set of systematics collected and analyzed as a result of this investigation. Because there was a comparatively small amount of remediation performed, one would not expect a significant change in the radionuclide concentration or physical characteristics within a small area. Attachment 12 provides photographs and locations of the various groupings of soil samples, both from tuna cans and excess soil sample bags.

One clear feature is that the samples from the third set of systematic samples do not appear similar in color to any of the other systematic samples, and all of the samples within the set look extremely similar, if not identical. This color uniformity coupled with the homogeneity of the low K-40, Ra-226, and progeny concentrations in an area with many visually distinct soil types within the survey unit led the investigators to conclude that the soil samples were not collected from B517 SU-002.

November 29 to December 3, 2012

Initial Investigation Report

The initial investigation report titled Investigation of Low Potassium Activity Concentrations in Soil Samples at Hunters Point Naval Shipyard is provided to the Navy and the NRC.

October 5 to 21, 2013

Update and Response to Navy Letter

On October 3, 2013, Navy management held a meeting with TtEC management to discuss a proposed update to the November 2012 initial investigation report. At the conclusion of this meeting, the Navy issued a letter (Attachment 13) on the same date requesting additional information.

TtEC agreed to reissue the initial report to include a status of corrective actions, as well as provide additional information on the investigation since submitting the initial report on November 29, 2012. The revised report incorporated the additional information requested by the Navy and updated the status of corrective actions taken by TtEC as of October 2013.

The Navy asked that TtEC identify the origin of the "low K-40" soil that may have been substituted in the sampling process (see question 1.c, Attachment 13). The investigators initially suspected the source of the "low K-40" soil was the Building 707 Triangle Area. Subsequent investigation of other potential source materials and analyses revealed that drill cuttings

consisting of greenish/grayish soil present on the ground floor of Building 253/211 have radioanalytical characteristics consistent with the "low K-40" soil. The radioanalytical results for these soil samples are contained in Attachment 14 and are summarized in Table 6.

TABLE 6

BUILDING 253/211 DRILL CUTTING SOIL SAMPLE RESULTS

Sample ID	Bi-214 (pCi/g)	Cs-137 (pCi/g)	K-40 (pCi/g)	Pb-214 (pCi/g)	Ra-226 (pCi/g)	Comments
04AB253-901	0.04346	0	0.1799	0.01653	0.02979	Green
04AB253-902	0.1198	0	3.64	0.1448	0.4302	Brownish-white
04AB253-903	0.001009	0	0.3812	0.1263	0.1748	Green
04AB253-904	0.3593	0.003745	8.103	0.4839	0.9601	Brown/White mix
04AB253-905	0.03367	-0.0001166	0.4592	-0.0007405	0.1023	Green
04AB253-906	0.1627	-0.002036	3.323	0.2025	0.3245	Dark Brown

The significance of this discovery was that if individuals decided to substitute samples from one source, it would be easier in the confines of a building where the actions are less likely to be observed by others. Either the Building 707 Triangle Area or the Building 253/211 drill cuttings, or both, may have been used as substitute soil samples, as both soil sources exhibit similar radiological characteristics. However, the investigators were unable to conclusively determine a source.

Copies of chain-of-custody forms, gamma static surveys, scan surveys, daily report information, and other ancillary information associated with the survey units listed in Tables 2 and 3 are included as Attachment 15.

Several other issues were identified through a review of survey data and chain of custody records (see request 1.d in Attachment 13):

- The same individual, Ray Roberson, was listed on the chain-of-custody form as having collected soil samples on May 31, 2012, at Survey Unit 304 at the same time he was listed as collecting soil samples at North Pier Survey Unit 11. The purpose for discussing Ray Roberson as the signatory on chain-of-custody forms is to pinpoint any unusual documentation; it is not meant to imply that Mr. Roberson was the sole cause or contributor to the anomalous data.
- Gamma static surveys were conducted in North Pier Survey Units 1, 8, 10, and 11 on May 31, 2012, from 14:52 to 16:25. The soil samples from these areas were documented as having been received at the Curtis and Tompkins laboratory from 16:12 to 16:45. If the soil samples had been collected appropriately, gamma static surveys would have been collected prior to collection of the soil samples.
- The collection of 1-minute statics in Survey Unit 1 on May 31, 2012, for 20 samples from 14:52 to 15:14 (22 minutes), Survey Unit 8 from 15:18 to 15:39 (21 minutes), Survey Unit 10 from 15:41 to 16:03 (22 minutes), and Survey Unit 11 from 16:04 to 16:25 (21 minutes) is not consistent with the typical times to collect 1-minute gamma static measurements (typically in the 28- to 32-minute range for 20 measurements). This is indicative that the gamma static measurements may have been collected in a smaller area than a typical survey unit.

- Chain-of-custody forms for the North Pier Survey Units 1, 8, 10, and 11 in Attachment 15 list the name of the sampler as "Ray Roberson," but the chain-of-custody form for Survey Unit 304 lists the name of the sampler as "R. Roberson."
- In the Site 707 Survey Unit 17 area, only a minor remedial action was taken. Prior to the remediation, 40 percent of the gamma static surveys exceeded the mean background plus three sigma investigation limit. On June 8, 2011, during the collection of soil samples, none of the gamma static survey measurements was above the mean background plus three sigma investigation level. This brings into question whether soil samples collected on June 8, 2011, were from the same area from which previous samples were collected.

All of the individuals who appeared to be involved based on these ancillary records are the same individuals identified as either signing as the sample collector for anomalous soil samples and/or the Health Physics Supervisor responsible for the sample collection. As such, these individuals received disciplinary action, and the associated data had already been rejected from inclusion in any FSS reports, as the associated resampling work was conducted in its entirety.

FINDINGS

The investigation was conducted to assess a discrepancy regarding the final systematic soil samples from B517 SU-002, which may not have been collected at the locations specified in the FSS report. The following are findings based on various possible scenarios that might have contributed to or caused the discrepancy:

- **Hypothesis: Did Instrument Error Cause the Discrepancy?**
    - The excellent correlation between on-site laboratory gamma spectroscopy results and the off-site gamma spectroscopy results for K-40, Ra-226, Bi-214, and Pb-214 effectively rules out instrument error as a cause for the anomalously low K-40, Ra-226, and progeny results. A comparison of onsite and offsite laboratory results is contained in Attachment 3.
- **Hypothesis: Did Laboratory Error Cause the Discrepancy?**
    - Curtis and Tompkins laboratory technicians are essentially blind of field sampling events.
    - Curtis and Tompkins chain of custody and sample control are robust and well controlled. Information provided by Curtis and Tompkins laboratory technicians corroborating chain of custody and sample control is contained in Attachment 9.
- **Hypothesis: Were the Anomalous Samples Collected at the Prescribed Depth?**
    - The idea that individuals sampling soil may have either consciously or accidentally sampled bedrock soil with low concentrations of K-40, Ra-226, and its progeny was not supported by either observations from the potholing or the subsurface sampling. Information is contained in Attachments 6 and 7.
    - No lithological evidence suggests that there is a bedrock soil layer, light gray in color and contiguous across B517 SU-002 at less than 2 feet bgs, that would account for anomalous readings in all 36 final systematic sample locations.

- **Hypothesis: Can Sample Results in Question Be Replicated?**
    - Samples collected during the investigation fail to yield results that match the uniform results for K-40, Ra-226, and progeny produced in the anomalous set of systematic results for each survey unit in question. Collection of soil samples at various depths within a survey unit does not result in replicating anomalously low K-40, Ra-226, and progeny results, with few exceptions. The exceptions noted are at depths significantly below the surface.
- **Hypothesis: Does Visual Inspection and Comparison Show Soil Homogeneity?**
    - Visual inspection of the survey units in question shows a wide variety of soil types, such that a consistent concentration of naturally occurring radioactive materials within an individual survey unit is unlikely.
    - Visual inspection of the anomalous soil samples as compared to other soil samples collected in the area shows a homogeneity in the anomalous soil samples that is not produced in any other soil sample collected within the area.
- **Hypothesis: Did Inappropriate Sampling Techniques Result in Discrepancies?**
    - All individuals interviewed claimed all appropriate soil sampling techniques were employed. Personnel interview information is contained in Attachment 9.
- **Hypothesis: Did Management Commitment to Schedule Create a Motive to Complete Work by Unethical Means?**
    - Field RCTs, lab technicians, and laborers from the sampling crew, when directly asked during individual interviews if they felt pressure to meet a schedule, all stated that they felt no pressure to complete work. The one exception was Steve Rolfe's comments that the work in the 707 Area had not been completed within the period of performance, and that there was an extended period of time that billable work had not been completed in Parcel E.
    - As the RCTs are subcontracted workers typically migrating to different projects at the completion of contract work, it is counterintuitive for them to complete work in an unethical manner. When the work is completed, the RCTs associated with the contract are released from work, and must seek employment on another contract. Thus, it appears to be beneficial to the RCTs for a work period to be extended as long as possible, such as through more remediation work resulting from systematic soil samples with concentrations of radionuclides of concern exceeding the radiological release criteria. Personnel interview information is contained in Attachment 9.

CONCLUSIONS

With the above hypotheses ruled out, there is one feasible explanation for samples exhibiting consistently low concentrations of K-40, Ra-226, and progeny, with visual characteristics that are similar, if not identical, but not representative of the heterogeneous soil types within the survey units in question. That explanation is that the persons listed as the sample collectors on the chain-of-custody forms, either by themselves or in conjunction with others, collected soil samples in areas outside the designated survey units. Note that Mr. Anthony Smith and Mr.

Joseph Cunningham were listed on the chain-of-custody forms but were not available for interviews because they had left the HPNS project before the investigation began.

The homogeneity of the soil sample results and visual characteristics indicate that the soil samples may have been collected from one homogeneous soil type, possibly from a small area. The soil referred to as the "road base" in the Survey Unit 22/23 areas of the Site 707 may be a source of the material, as its radionuclide signature is similar to that of the soil from the "anomalous" samples, and the grayish color is similar. Sample results collected from drill cuttings from another contractor and stored in Buildings 253/211 show similar "low K-40" results as discussed previously. This may have also served as the source of the "low K-40" soil. Additionally, in the case of sample collection at the North Pier, soil samples were collected from four survey units at the North Pier and one other survey unit all in one day according to the chain-of-custody forms. This quantity of sample collection performed in one day is unrealistic based on interviews with members of the sampling team. The sample collection rate of one to two survey units per day appears to be corroborated by the sample collection rate performed for this investigation.

The motivation for collecting soil samples in areas outside the assigned survey units is unclear. The radioanalytical and physical evidence contradicts the oral testimony provided by members listed on the sampling section of the chain-of-custody forms. Note that multiple survey units in the Site 707 area were remediated primarily as a result of Cs-137 concentrations exceeding the release criterion. The five survey units within the North Pier that showed anomalous results provided a basis for an FSS report to radiologically release the North Pier.

It is counterintuitive for RCTs and HPNS supervisors to want to complete the release of an area rapidly, as this may shorten the length of employment. On the other hand, if the RCT and/or supervisors believed that rapidly finishing survey units would result in future work awards from the Navy at HPNS, or if they wanted to collect samples from an area that did not require significant manual effort, such as the uses of picks and chipper hammers, some motivation to sample in an area outside a survey unit may exist. It is not believed that the anomalous soil samples were a result of sabotage, as the soil sample results all yielded radionuclide of concern concentrations well below any respective release criterion.

To maximize the Navy's confidence in the overall quality of data provided in the future, and to minimize the likelihood of accidental and/or purposeful inappropriate soil sampling to the maximum extent possible in the future, TtEC developed corrective actions to strengthen the quality of all aspects of the soil sample collection and quality control review process. For example, one corrective action focused on retraining the field teams in proper sample collection procedures including proper use and documentation of chain-of-custody forms. As another example, to send a message to all workers that any apparent deviation from sampling protocol will not be tolerated, TtEC proactively removed the three remaining RCTs who had signed the majority of the chains of custody for the identified unacceptable soil samples from any TtEC projects, and severely disciplined the two health physics supervisors responsible for supervising the RTCs. As a third example, to provide increased soil sample collection quality across the entire process, TtEC significantly increased the number of quality control surveillances by the Project QC Manager or another authorized independent party during the final systematic soil sample collection process. In addition to close personal scrutiny by health physics professionals, TtEC also uses Microsoft Excel conditional formatting in soil sample result spreadsheets to

screen and identify soil sample results for closer review and evaluation. A detailed listing of each of the corrective actions implemented by TtEC is included in the "Corrective Actions" section.

Since implementing these corrective actions, TtEC has performed numerous quality control surveillances to confirm the corrective actions were correctly implemented. These inspections have validated that the corrective actions were implemented in accordance with TtEC's plan. More importantly, since implementing these corrective actions, a recurrence of anomalous sample results similar to the results identified in this investigation report has not occurred

ROOT CAUSE

A TtEC Quality Event RCA summary form is provided as Attachment 16. This form is used to conduct the causal analysis of events that resulted in a deficient condition. Each item identified as a cause has a corrective action that is associated with it.

PROCESSES THAT MAY HAVE CONTRIBUTED TO THE CONDITION

Using the Systematic Cause Analysis Technique (SCAT), the following potential processes that may have contributed to mishandling of soil samples and falsified data are listed. The corrective actions in the following section provide a means to prevent the same events from occurring in the future.

- **IMPROPER FOCUS ON PRODUCTION** – The HPNS project management team may have conveyed a message to workers that completion of work by a scheduled date was of undue importance.

- **INADEQUATE FIELD SUPERVISION** – The HPNS project management team may not have shown adequate supervision over health physics supervisors. Health physics supervisors may not have provided adequate supervision over radiation control technicians and laborers.

- **INADEQUATE QUALITY CONTROL SURVEILLANCES** – HPNS QC personnel may not have conducted a sufficient number or adequately detailed surveillances during soil sample collection.

- **INADEQUATE REVIEW OF DATA** – The Radiation Safety Officer may not have sufficiently reviewed radioanalytical data collected during the soil sampling process.

- **INADEQUATE CONCERN FOR OTHERS** – HPNS individual workers may not have questioned actions by co-workers that appeared to be nonstandard.

CORRECTIVE ACTIONS

The following is an update on corrective actions from the initial investigation report dated November 29, 2012. The corrective actions are shown in italics, followed by a listing of the status of the corrective action, as well as a reference to evidence of completion.

1. *Take disciplinary action for individuals identified as the sample collector on the chain-of-custody forms for sample sets containing anomalous data reflecting uniformly low K-40, Ra-226, and progeny concentrations. Disciplinary action will also be taken with the*

management team, quality control team, and radiological supervision responsible for overseeing and inspecting the work.

Disciplinary action has been taken in that the three RCTs still working at the site and whose signatures appeared as sample collector on the chain-of-custody forms for anomalous samples in the survey units as identified in Tables 2 and 3 of the report were removed from TtEC projects. Additionally, the two TtEC health physics supervisors who were responsible for the soil sample collection work in the survey units with the anomalous samples were given one month leave without pay, and letters of caution. One of the two Health Physics Supervisors is no longer employed by TtEC. All other project management personnel who were involved in the sampling process or could have identified the sampling malfeasances, including the project management team, quality control team, and radiation safety team, were issued letters of caution.

This action item is closed.

2. *Retrain all personnel involved in sampling on proper sampling as detailed in SOP HPO-Tt-009, or corporate equivalent procedure, focusing on sample collection depth, representativeness of soil sample, and use and decontamination of equipment.*

   All individuals directly involved in soil sample collection at HPNS were provided refresher training on December 5, 2012, by the site Radiation Safety Officer Representative (RSOR) on proper soil sample collection per SOP HPO-Tt-009, as well as proper filling out of chain-of-custody forms. Training sign-in sheets are provided in Attachment 17. Refresher training is held annually.

   This action item is closed.

3. *Train all individuals at HPNS involved with soil sampling on importance of ethical behavior, and company and personal ramifications of falsified data. Note that this training has already been initiated with TtEC employees and subcontractors associated with sample collection.*

   All individuals involved in soil sample collection, as well as virtually every TtEC employee and subcontractor on the HPNS site, were provided training on ethical behavior by the HPNS RSOR on November 28, 2012; January 29, 2013; February 12, 2013; and January 30, 2014. A copy of the training presentation and copies of sign in sheets are provided in Attachment 18.

   This action item is closed.

4. *Determine, with Navy input, whether survey units identified for possible resampling in Table 3 and/or other survey units need to be resampled.*

   TtEC, under its own initiative, resampled all survey units listed in Table 3 with the exception of the Parcel C Trench Survey Units 234, 238, and 242. Any survey units exhibiting activity concentration exceeding the release criterion for a respective radionuclide of concern were remediated and resampled until all release criteria had been met. All suspect data, including anomalous soil sample data and gamma static survey results, were rejected.

   FSS reports are in the process of being drafted for survey units associated with the North Pier and the Former 707 Triangle Area. Each FSS report will contain a reference to data being rejected due to identification during the quality assurance review process.

The four Parcel C trench units listed in Table 3 had already been backfilled, and draft SUPR reports submitted to the regulatory agencies for concurrence. TtEC submitted recommendations concerning Trench Units 234, 238, 242, and 302 in the October 2013 investigation report. A summary of TtEC's final recommendations for these four trench units has been updated and is included as Attachment 19.

Ancillary soil samples were collected on January 14, 2013 outside of the footprint of the trench backfill for Trench Unit 234. The results were compared to the original soil systematic sample results and were found to be similar, which indicates the original low K-40 results were representative of subsurface conditions.

Trench Units 238 and 242, located outbound of the former shoreline in Parcel C, reported low K-40 concentrations. Statistical analysis of original and ancillary data for Trench Units 238 and 242 indicated the samples may be representative of the trench conditions, but the data were not conclusive. Fill encountered in the trench excavations was compared to fill materials described in the Site Conceptual Model for Parcel C (Attachment 1). Both trench units contained greenish gray soils as shown in excavation photographs, and are in proximity to other locations with documented Franciscan-derived fill material. Franciscan-derived fill is well documented as having very low levels of K-40 and other isotopes. Based on this association, the low K-40 concentrations reported for these trenches were found to be correlative to typical concentrations observed at Parcel C in the presence of Franciscan-derived fill material.

Trench Unit 302 has been re-excavated, and soil samples re-collected and analyzed. All soil samples were less than the HPNS site radiological release criteria. A revised SUPR for Trench Unit 302 was submitted to the Navy for review in January 2014.

This action item is closed.

5. *Continue to resample, and remediate as necessary, survey units identified in Table 2. Once the survey units have verified sample analytical data supporting a recommendation of radiological free release, final status survey reports will be prepared and submitted to the Navy for review and approval.*

   TtEC resampled all survey units listed in Table 2. Any survey units exhibiting activity concentrations exceeding the release criterion for a respective radionuclide of concern were remediated and resampled until all release criteria were met. All suspect data, including anomalous soil sample data and gamma static survey results, were rejected. FSS reports are in the process of being drafted. Each FSS report will contain a reference to data being rejected due to identification during the quality assurance review process.

   This action item is closed.

6. *Implement a protocol such that an independent QC person, or health physicist, will verify through a quality control surveillance that a minimum of 10 percent of final systematic samples for each survey unit have been collected in accordance with the appropriate work documents (SOPs, Task-specific Plans, etc.).*

   A member of the HPNS quality control team has conducted a surveillance of a minimum of 10 percent of final systematic sample collection. Issues identified during the surveillances have been documented and are corrected. Documentation of QC surveillances is contained in Attachment 20.

   This action item is closed.

7. *Develop and implement a protocol for reviewing sample sets to identify radionuclide concentration trends for radionuclides quantified in gamma spectroscopy reports that are inconsistent with previous sampling within a survey unit and/or surrounding survey units. Note that this will include K-40 and other radionuclides that are not radionuclides of concern.*

   As soil sample results are imported into the database, the results are screened by the use of Microsoft excel filters to highlight any results with K-40 at concentrations less than 5 pCi/g. Note that low K-40 soil exists at HPNS as shown by soil sample results in Attachment 2, and in the site conceptual model as shown in Attachment 1. For any results that meet this criterion, the corporate Radiation Safety Officer is notified by e-mail to make a further evaluation. The number of low K-40 results, the location of the samples collected, and previous data for the survey unit (if applicable) are used to determine whether the data are suspect. Using this process provides another level of quality assurance to ensure that soil sample collection is representative of soil sample from the respective survey units.

   This action item is closed.

FINAL CONCLUSION

Collectively, completion of the above action items has resulted in high-quality FSS results. These corrective actions ensured that all samples were collected and handled in full compliance with the Sampling and Analysis Plan. TtEC has not had a recurrence of the type of anomalous soil sample results that led to this investigation, indicating that the corrective actions have addressed the problem.

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ATTACHMENT 1

SITE CONCEPTUAL MODEL FOR LOW K-40 SOIL

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Site Conceptual Model for Hunters Point Naval Shipyard Parcel C Soil Containing Low Concentrations of Potassium-40, Radium-226, Bismuth-214 and Lead-214

During the wartime expansion of Hunters Point Naval Shipyard (HPNS), the Navy moved vast quantities of soil in and around Parcel C as can be seen in the photograph provided on Figure 1. Most of Parcel C consists of flat lowlands that were constructed by placing borrowed fill material from various sources, including crushed serpentinite bedrock from the adjacent highland. These historical cut, fill, and grading activities support the conceptual site model (CSM) that the wide-range of potassiuim-40 (^{40}K) values identified in the soil sample results from Parcel C trenches correlates to the site geology and widely varying soil types used for fill. Figure 1 also includes the relevant section of the 1998 Preliminary Geologic Map of the San Francisco South 7.5' Quadrangle and Part of the Hunters Point 7.5' Quadrangle, San Francisco Bay Area, California (Bonilla 1998) to demonstrate the significant variety of soil types within Parcel C. As mapped by the United States Geological Survey (USGS), the upland portion of HPNS consists of Franciscan bedrock and includes serpentine, chert, altered volcanic rocks, and interbedded sandstones and shales.

Figure 2 shows the Parcel C excavated storm drain and sanitary sewer trenches, identifies the geographic distribution of those Parcel C trenches with low ^{40}K results, and shows the approximate location of the 1935 shoreline. Also shown are nearby groundwater monitoring wells. The near surface (less than 10 feet below ground surface) lithologies mapped in the boring logs are varied and range from dark gray serpentinite sands, clays, and gravels to yellowish brown clayey sands with serpentinite gravels. The boring logs are included as Attachment 1, and the monitoring well locations are identified on Figure 2.

Survey Unit (SU) 326 from Parcel C provides an example of the variety of soil types located at HPNS. Nineteen of the twenty-one samples from SU 326 were provided for classification of color and soil type post-analytical processing. The samples were classified using the Munsell Soil Color Charts (2009) and the Unified Soil Classification System (USCS) visual-manual procedure (Howard 1986). As part of the analytical procedure, soil samples were either oven or air dried, and then passed through a number 10 sieve until enough soil was acquired for analysis (300 to 400 grams). The remainder of each soil sample was bagged and labeled. This remaining bagged soil is what has been described below. Given that the soil samples were baked and a portion mechanically removed, the soil colors and USCS classifications provided below have been generalized. Examples from samples 6 and 11 were unavailable for examination since the excess soil had been sent for off-site laboratory strontium-90 analysis as required by TtEC's Sampling and Analysis Plan. Since SU 326 remains open, photographs were taken at 15 of the soil sample collection locations as shown on Figure 3. Photographs of the samples discussed below are shown on Figure 4.

The 19 soil samples were grouped as follows to evaluate radiological characteristics in relation to soil type and/or color:

- Four samples with ^{40}K results below 1 picocurie per gram (pCi/g)
- Seven samples with ^{40}K results between 1 and 4 pCi/g
- Seven samples with ^{40}K results between 4 pCi/g and 19 pCi/g
- One sample with ^{40}K results greater than 20 pCi/g

Two of the four samples with ^{40}K results below 1 pCi/g (Samples 16 and 17) are composed of the same material: light greenish gray (GLEY1 7/1) angular coarse sands of bluish green lithic fragments with minor iron oxide staining. The remaining two samples (Samples 9 and 12) are composed of light gray (10YR 7/2) coarse sand and fine gravels of angular volcanic, serpentine, and gray sandstone fragments. The lithology and color of all four samples are consistent with Franciscan-derived fill materials.

Five of the seven samples with ^{40}K results between 1 and 4 pCi/g (Samples 1, 13, 14, 18, and 21) are composed of light gray (10YR 7/2) to light greenish gray (GLEY1 7/1) coarse sand and fine gravel composed of angular volcanic, serpentine, and gray sandstone fragments of the Franciscan Formation. The remaining two samples vary in color. Sample 3 is composed of dark grayish brown (10YR 4/2) silt and coarse angular sands composed of gray and brown sandstone and volcanic fragments. Sample 8 is composed of pale brown (10YR 6/3) fine to coarse sands of angular volcanic, serpentine, and gray sandstone fragments. Despite the range in color differences, the lithology and color of all seven samples are consistent with Franciscan-derived fill materials.

The seven samples with ^{40}K results between 4 pCi/g and 19 pCi/g (Samples 2, 4, 5, 7, 10, 15, and 19) are composed of the same material: dark grayish brown (10YR 4/2) angular fine gravels and sand composed of volcanics and gray sandstone fragments of the Franciscan Formation. The lithology and color of all seven samples are consistent with Franciscan-derived fill materials.

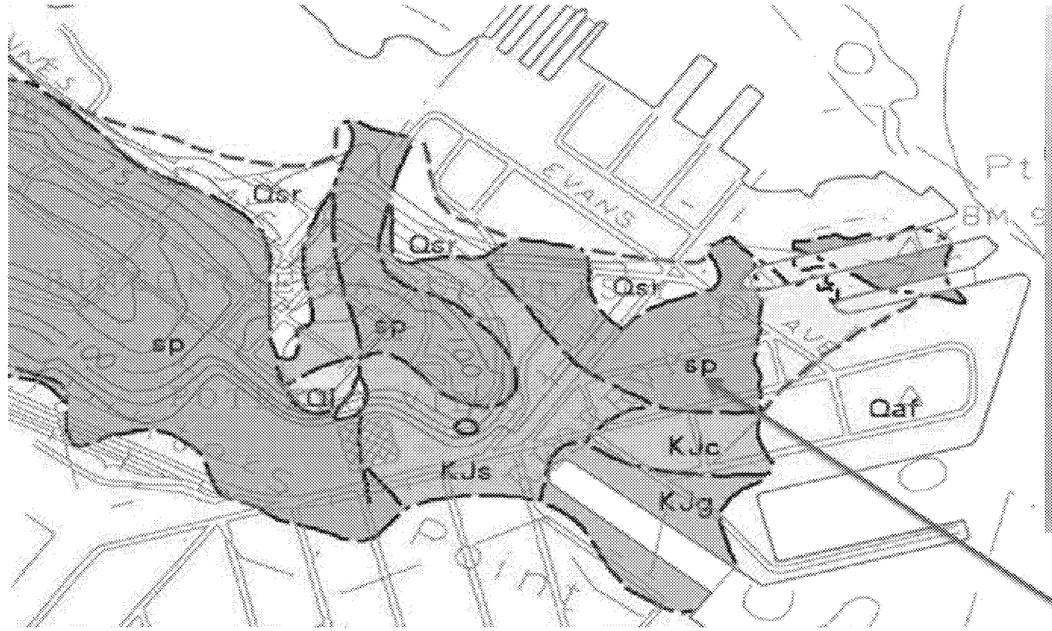
The one sample with ^{40}K results greater than 20 pCi/g (Sample 20) is composed of gray (GLEY1 6/1) angular coarse sand and fine gravels of gray sandstone likely derived from Franciscan gray sandstone (greywacke) with silt.

In conclusion, TtEC has demonstrated a direct correlation between the various soil types and the ^{40}K results identified in the Parcel C trench survey units. This conclusion is based on:

1) The CSM that the vast quantities of soil moved in and around Parcel C during wartime expansion of HPNS resulted in widely varying soil types used for fill
2) The significant variety of soil types within Parcel C based on the USGS map
3) The varying ^{40}K analytical results correlated with the soil descriptions

FIGURES

Bonilla, M.G., 1998. Preliminary Geologic Map of the San Francisco South 7.5' Quadrangle and Part of the Hunters Point 7.5' Quadrangle, San Francisco Bay Area, California.



Note the Navy's grading (cut) and movement of the Franciscan Formation including serpentine, Chert, and altered volcanic, and sandstone material on the hill to expand HPS.

sp Serpentine
Hard to soft, generally greenish gray; contains small bodies of grabbro and diabase.

Qaf Artificial fill
Clay, silt, sand, rock fragments, organic matter, and man-made debris.

KJc Chert
Hard chert interbedded with firm shale; chert layers generally two or three inches thick, shale layers less than one inch thick; generally grayish red.

KJg Greenstone
Altered volcanic rocks, fine grained, mostly basalt; hard where fresh, but weathered and firm to soft in most exposures; commonly grayish olive to moderate olive gray where moderately weathered, dark yellowish orange to light brown where highly weathered.

KJs Sandstone and shale
Interbedded sandstone and shale, hard where fresh and intact, soft where weathered or sheared. Commonly medium dark gray where fresh, olive gray to yellowish brown where moderately weathered, and yellowish orange to yellowish gray where highly weathered.

Ql Landslide deposits
Composition and structure depend on the geologic formation involved and type of landslide.

Qsr Slope debris and ravine fill
Stony silty to sandy clay, locally silty to clayey sand or gravel; yellowish-orange to medium gray, unstratified or poorly stratified. Where it overlies the Merced or Colma Formation it is commonly a silty to clayey sand, or gravel.

BASE REALIGNMENT AND CLOSURE
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FIGURE 1

HISTORICAL PARCEL C
CONSTRUCTION AND GEOLOGIC MAP

HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA

REVISION: –
AUTHOR: A.CRABTREE
PROJECT NO:
FILE: SEE BELOW

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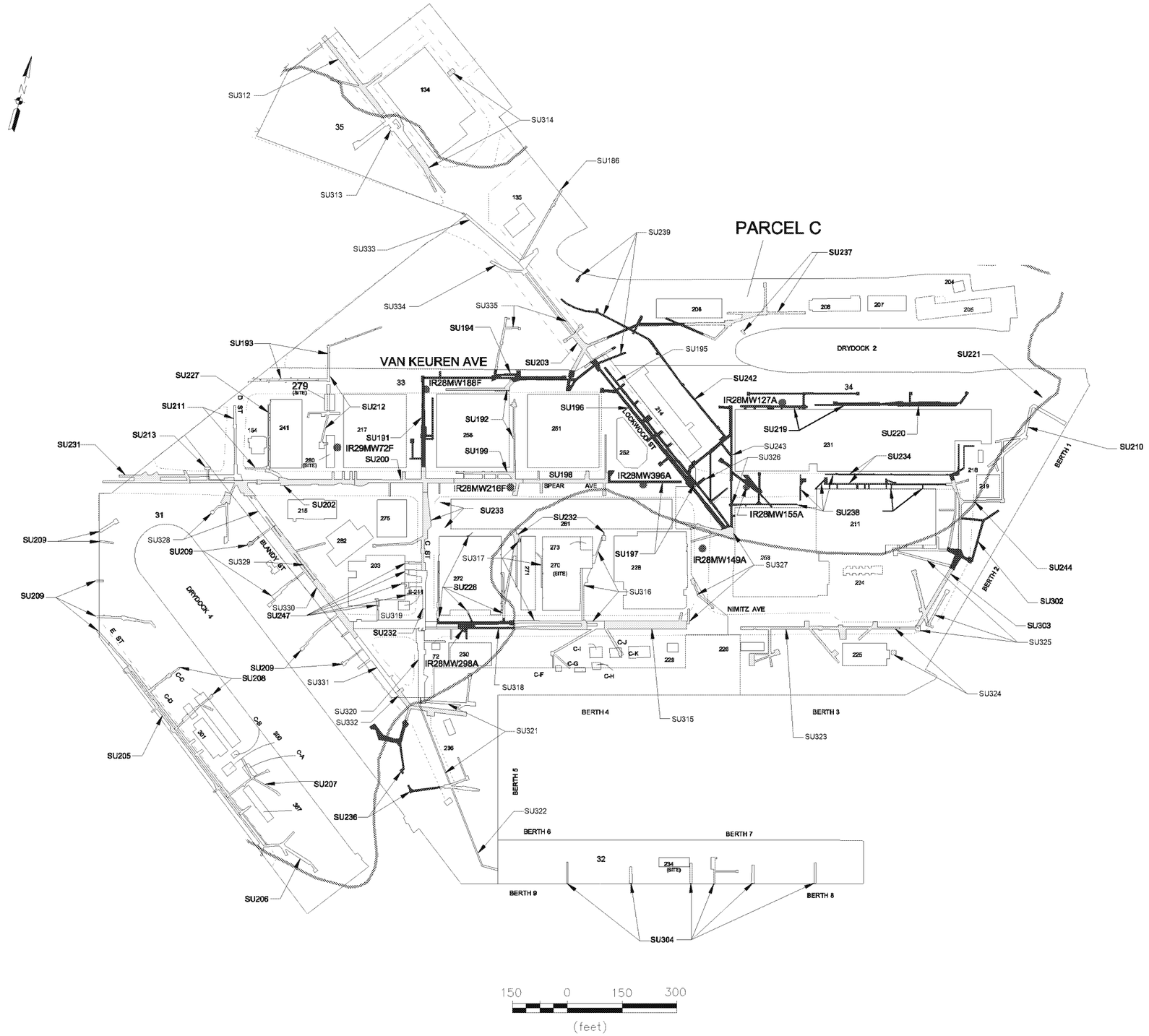

LEGEND

- SU 191 — SURVEY UNIT (SU)
- 34 — WORK AREA BOUNDARY AND NUMBER
- IR BOUNDARY AND NUMBER
- 140 — IMPACTED BUILDING BUILDING NUMBER
- 142 (SITE) — IMPACTED BUILDING FORMER BUILDING LOCATION
- 128 — NON-IMPACTED BUILDING BUILDING NUMBER
- IR28MW216F — MONITOR WELL ID AND LOCATION
- OTHER SURVEY UNITS
- 1-5 ^{40}K RESULTS LESS THAN 5pCi/g
- > 5 ^{40}K RESULTS LESS THAN 5pCi/g
- 1935 SHORELINE

Parcel C SS/SD Survey Units

SU with 1-5 ^{40}K results less than 5 pCi/g	SU with > 5 ^{40}K results less than 5 pCi/g	Parcel C Phase
186	191	Ph 1
192	194	Ph 1
198	195	Ph 1
199	196	Ph 1
200	197	Ph 1
202	219	Ph 1
203	220	Ph 1
205	234	Ph 1
208	236	Ph 1
213	238	Ph 1
231	239	Ph 1
232	242	Ph 1
233	243	Ph 1
237	302	Ph 1
244		Ph 1
303		Ph1
312	318	Ph2
314	326	Ph2
315		Ph2
317		Ph2
323		Ph2
324		Ph2
327		Ph2
329		Ph2
330		Ph2
332		Ph2

42 of the 66 (63.6%) Parcel C SUs have Low ^{40}K results

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FIGURE 2

PARCEL C PHASE I AND II SURVEY UNIT
POTASSIUM-40 RESULTS

HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA

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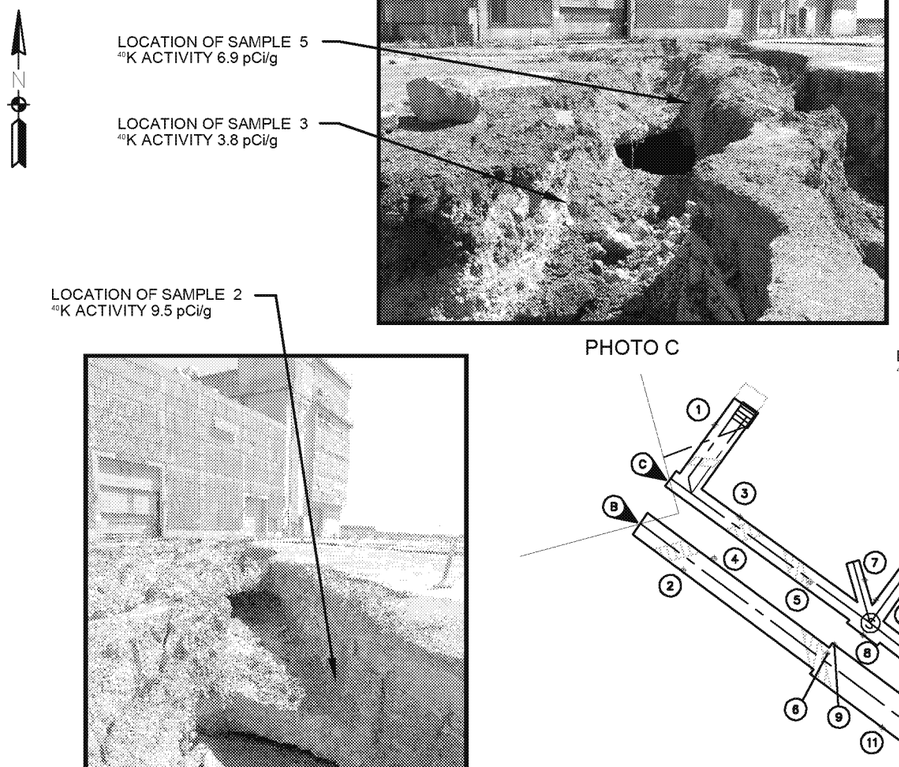

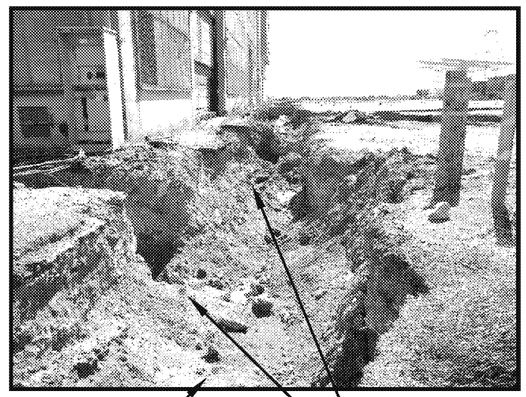

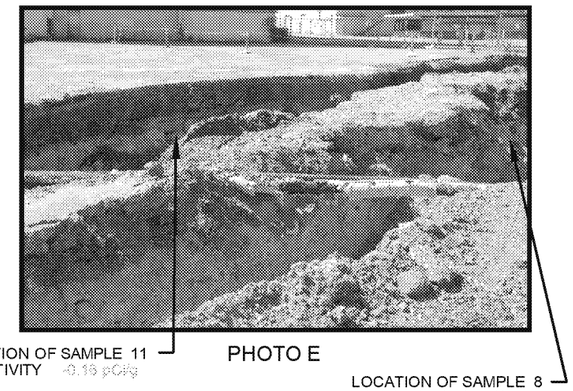

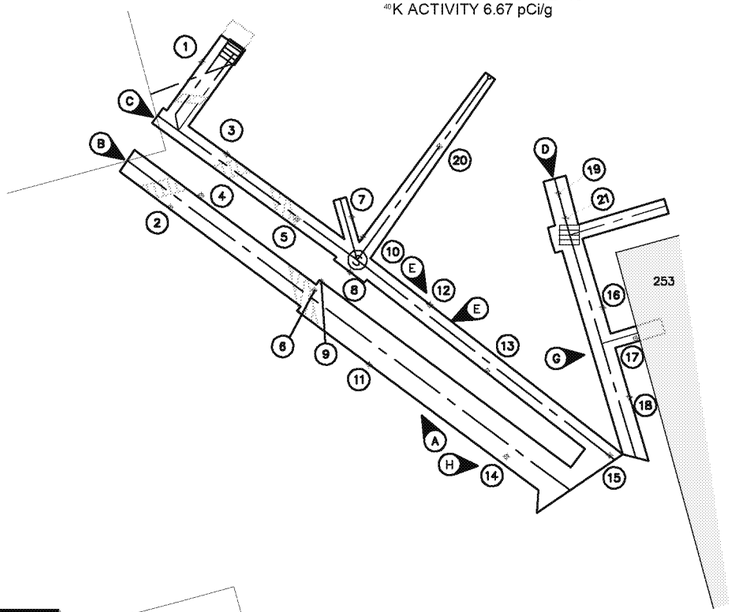

LEGEND:

-0.12 pCi/g — LOW POTASSIUM–40

— 40K POTASSIUM–40 SAMPLE LOCATION AND ID NUMBER

G — PHOTO LOCATION AND ID

— CONCRETE

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FIGURE 3
PHOTOS AND POTASSIUM-40 RESULTS
REPRESENTATIVE SAMPLE LOCATIONS, SURVEY UNIT 326

HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA

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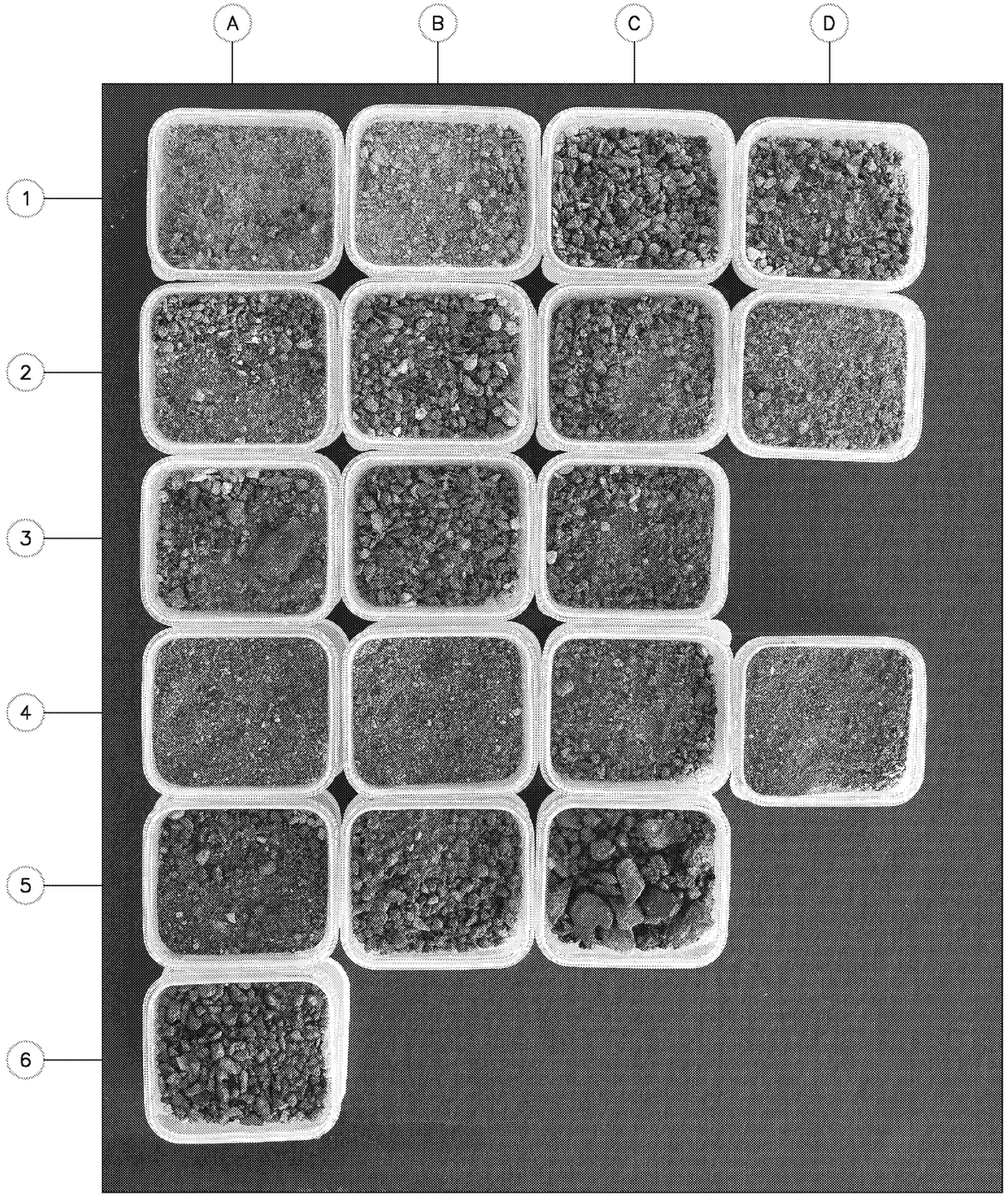

	SU326 SOIL SAMPLE KEY			
	A	B	C	D
1	17	16	9	21
2	8	21	13	18
3	1	14	3	
4	19	5	15	4
5	2	7	10	
6	20			

<1 pCi/g
1-4 pCi/g
4-19 pCi/g
>19 pCi/g

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PARCEL C

FIGURE 4
SURVEY UNIT 326 SOIL SAMPLES

HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA

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